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TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371

ATTORNEY 'S DOCKET NUMBER	
N8084-EAS	
U.S. APPLICATION NO. (If known, see 37 CFR 1.5)	
10/030025	

INTERNATIONAL APPLICATION NO.	INTERNATIONAL FILING DATE	PRIORITY DATE CLAIMED
PCT/IT00/00261	June 26,2000	July 2,1999

TITLE OF INVENTION

POWER SUPPLY CIRCUIT OF AN ELECTRIC MOTOR AND CORRESPONDING CONTROL METHOD

APPLICANT(S) FOR DO/EO/US

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Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. [X] This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. [ ] This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. [ ] This is an express request to begin national examination procedures (35 U.S.C. 371(f)). The submission must include items (5), (6), (9) and (21) indicated below.
4. [ ] The US has been elected by the expiration of 19 months from the priority date (Article 31).
5. [ ] A copy of the International Application as filed (35 U.S.C. 371(c)(2))
   a. [ ] is attached hereto (required only if not communicated by the International Bureau).
   b. [XX] has been communicated by the International Bureau.
   c. [ ] is not required, as the application was filed in the United States Receiving Office (RO/US).
6. [ ] An English language translation of the International Application as filed (35 U.S.C. 371(c)(2)).
   a. [ ] is attached hereto.
   b. [ ] has been previously submitted under 35 U.S.C. 154(d)(4).
7. [ ] Amendments to the claims of the International Aplication under PCT Article 19 (35 U.S.C. 371(c)(3))
   a. [ ] are attached hereto (required only if not communicated by the International Bureau).
   b. [ ] have been communicated by the International Bureau.
   c. [ ] have not been made; however, the time limit for making such amendments has NOT expired.
   d. [ ] have not been made and will not be made.
8. [ ] An English language translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371 (c)(3)).
9. [X] An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).
10. [ ] An English lanugage translation of the annexes of the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11 to 20 below concern document(s) or information included:

11. [ ] An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
12. [ ] An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
13. [ ] A FIRST preliminary amendment.
14. [ ] A SECOND or SUBSEQUENT preliminary amendment.
15. [ ] A substitute specification.
16. [ ] A change of power of attorney and/or address letter.
17. [ ] A computer-readable form of the sequence listing in accordance with PCT Rule 13ter.2 and 35 U.S.C. 1.821 - 1.825.
18. [ ] A second copy of the published international application under 35 U.S.C. 154(d)(4).
19. [ ] A second copy of the English language translation of the international application under 35 U.S.C. 154(d)(4).
20. [ ] Other items or information:

531 Rec'd PCT/PT 02 JAN 2002

U.S. APPLICATION NO. (if known, see 37 CFR 1.5)	INTERNATIONAL APPLICATION NO.	ATTORNEY'S DOCKET NUMBER
10/030025	PCT/IT00/00261	N8084-EAS

21. The following fees are submitted:	CALCULATIONS PTO USE ONLY	
BASIC NATIONAL FEE (37 CFR 1.492 (a) (1) - (5)):		
Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or JPO **$1040.00**		
International preliminary examination fee (37 CFR 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO **$890.00**		
International preliminary examination fee (37 CFR 1.482) not paid to USPTO but international search fee (37 CFR 1.445(a)(2)) paid to USPTO **$740.00**		
International preliminary examination fee (37 CFR 1.482) paid to USPTO but all claims did not satisfy provisions of PCT Article 33(1)-(4) **$710.00**		
International preliminary examination fee (37 CFR 1.482) paid to USPTO and all claims satisfied provisions of PCT Article 33(1)-(4) **$100.00**		
ENTER APPROPRIATE BASIC FEE AMOUNT =	$ 890.00	
Surcharge of **$130.00** for furnishing the oath or declaration later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492(e)).	$	

CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE	
Total claims	- 20 =		x **$18.00**	$
Independent claims	- 3 =		x **$84.00**	$
MULTIPLE DEPENDENT CLAIM(S) (if applicable)			+ **$280.00**	$

TOTAL OF ABOVE CALCULATIONS =	$ 890.00
☐ Applicant claims small entity status. See 37 CFR 1.27. The fees indicated above are reduced by 1/2. +	$
SUBTOTAL =	$ 890.00
Processing fee of **$130.00** for furnishing the English translation later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492(f)).	$
TOTAL NATIONAL FEE =	$ 890.00
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). **$40.00** per property +	$
TOTAL FEES ENCLOSED =	$ 890.00
Amount to be refunded:	$
charged:	$

a. ☒ A check in the amount of $ 890.00 to cover the above fees is enclosed.

b. ☐ Please charge my Deposit Account No. _____ in the amount of $ _____ to cover the above fees. A duplicate copy of this sheet is enclosed.

c. ☒ The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 23-0035. A duplicate copy of this sheet is enclosed.

d. ☐ Fees are to be charged to a credit card. **WARNING:** Information on this form may become public. **Credit card information should not be included on this form.** Provide credit card information and authorization on PTO-2038.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137 (a) or (b)) must be filed and granted to restore the application to pending status.

SEND ALL CORRESPONDENCE TO:

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NAME

44,336
REGISTRATION NUMBER

POWER SUPPLY CIRCUIT OF AN ELECTRIC MOTOR AND CORRESPONDING CONTROL METHOD

DESCRIPTION

Technical field

The present invention relates to a power supply circuit of the stabilized, or at least regulated, voltage type, for an electric motor, for the purpose of maximizing the efficiency of the motor or of regulating its speed, particularly for an asynchronous electric motor, and especially - but not exclusively - a single-phase asynchronous motor.

The present invention also relates to an electric motor comprising a power supply circuit of the stabilized voltage type, as well as a method for controlling the supply voltage of an electric motor.

Prior art

In the design of electric motors, it is assumed that the power supply is at a constant voltage, and the motor is designed with the object of optimizing the performance of the motor at the design voltage, typically ranging from 200 to 230 V, or having other values according to the mains voltage used in the country in which the motor is to be used.

In fact, the supply voltage is not constant, as a result of possible voltage fluctuations in the mains, and also as a result of small differences in voltage in the various mains systems of the individual countries in which the motor may be used. Typically, the mains voltage may be as much as 255 V. In order to enable a motor designed for a specific voltage to operate correctly in conditions where the voltage may vary by as much as several tens of volts, control circuits based on the principle of slicing, particularly triac and chopper control circuits, are used at present. These circuits have some disadvantages, including a high harmonic content of the supply voltage to the motor (particularly for triac controllers) and a high cost, owing to the necessity of using high-voltage components and complicated control circuits. The production of chopper control circuits also has the disadvantage of a certain structural complexity due to the necessity of using controlled switches which operate at a high frequency with respect to the mains frequency.

Objects of the invention

The object of the present invention is to provide a new type of control circuit for the power supply of a motor, particularly an asynchronous motor, which can be used to set or stabilize the supply voltage while avoiding the disadvantages of traditional slicing circuits.

A further object of the present invention is to provide a new method of controlling the power supply to an electric motor, particularly an

asynchronous motor, which enables a stabilized supply voltage to be obtained without the disadvantages of the conventional methods.

More particularly, the object of the present invention is to provide a circuit and a control method which do not require expensive components, which avoid the use of high-frequency switching elements, and which do not require mains filters for the elimination of electromagnetic noise.

Summary of the invention

These and further objects and advantages, which the following text will make clear to a person skilled in the art, are essentially obtained by means of a circuit characterized in that it comprises means of measuring a difference between a mains voltage and a reference voltage, and means for generating an alternating correction voltage whose frequency is equal to the frequency of the mains voltage, and which is phase-shifted with respect to said mains voltage, the phase shift between the mains voltage and the correction voltage being proportional to the difference between the mains voltage and the reference voltage, and said correction voltage being added to the mains voltage.

Essentially, therefore, the invention is based on the idea of subtracting from, or adding to, the mains voltage an alternating wave at low voltage (correction voltage), whose phase with respect to the mains voltage is controlled in such a way that the sum of the two voltages supplies a stabilized voltage to the motor.

In one practical embodiment, it is possible to generate the correction voltage by using a full bridge consisting of four controlled switches, whose switching generates the correction voltage, which in this case is a square-wave voltage. A control logic switches the controlled switches according to the difference between the mains voltage and the value of the stabilized voltage which is required for the motor. The bridge of controlled switches is connected, through a direct-current branch of the bridge, to a virtually continuous voltage source.

Although this virtually continuous voltage source may be a source supplied from the same mains voltage which has been suitably processed, in a particularly advantageous embodiment the continuous voltage is obtained by using the inductive energy of the motor. For this purpose, a storage device in which the inductive energy is stored during certain phases of the operating cycle, and transferred to the motor in the remaining phases, can be located in the direct-current branch of the bridge of controlled switches. In one practical embodiment, the storage device consists of a capacitor or a group of capacitors.

Further advantageous embodiments of the circuit according to the invention and of the corresponding motor, as well as of the motor power supply method, are indicated in the attached claims and will be described in greater detail below with reference to one embodiment.

Brief description of the drawings

The invention will be more clearly understood from the description and the attached drawing, which shows a non-restrictive practical embodiment of the invention. More particularly, in the drawing,

Fig. 1 shows a simplified diagram of the motor and of the corresponding supply voltage control circuit;

Fig. 2 shows a block diagram of the control logic;

Figs. 3A to 3D show the diagram of the motor and of the corresponding control circuit in four successive stages of operation;

Fig. 4 shows a diagram of the mains voltage, the motor supply voltage, the motor supply current, the voltage of the storage capacitor and the control voltage;

Figs. 5A-5E show the individual curves of Fig. 4 separately;

Figs. 6A to 6I show the waveforms at the various points of the control logic; and

Fig. 7 shows the harmonic content of the voltage to the motor.

Detailed description of the preferred embodiment of the invention

Fig. 1 shows schematically a constant-voltage power supply circuit for a single-phase asynchronous motor. The number 1 indicates the alternating voltage source, consisting, for example, of the electrical power mains, a generator unit, or another source. The number 3 indicates in a general way the motor which is represented schematically as an inductor 5 in parallel with a resistor 7.

The motor 3 and the voltage source 1 are connected in a full bridge consisting of controlled switches 11, 12, 13, 14, consisting for example of the same number of MOSFETs or other switching devices controlled by a control logic 17 whose outputs 17A-17D open and close the switches 11-14.

A direct-current branch 18 comprising a storage capacitor 19 is connected in parallel with the bridge 11-14. As will be made clear in the following description, the switching of the switches 11-14 is controlled by the control logic 17 according to the voltage across the terminals of the motor 3 and the phase of the supply voltage, in such a way as to generate a square-wave voltage which has a frequency equal to the frequency of the supply voltage supplied by the source 1, but is phase-shifted with respect

to the latter, and which is added to or subtracted from the supply voltage to produce a voltage equal to the desired voltage across the terminals of the stator winding of the motor 3. The control logic modifies the phase of the square wave with respect to the phase of the supply voltage supplied by the source 1, to produce a voltage equal to the desired voltage across the terminals of the motor. The necessary voltage for the supply of the bridge 11-14 for generating the square wave is obtained by storing in the capacitor 19 some of the inductive energy of the motor 3.

The operation of the circuit described briefly above will be explained with reference to the diagrams in Figs. 4, 5A-5D and Figs. 3A-3D. Fig. 4 shows the following curves superimposed on each other:

- V1: mains voltage supplied by the voltage source 1;
- V2: square-wave voltage supplied by the full bridge 11, 12, 13, 14, supplied from the energy stored in the capacitor 19;
- Vm: voltage across the terminals of the motor 3 (voltage across the winding);
- Im: current passing through the motor 3;
- Vc: voltage across the terminals of the storage capacitor 19.

For greater clarity, the five aforesaid curves are shown once again, separately from each other, in the diagrams in Figs. 5A-5E.

As shown in Fig. 4, the voltage V2 applied to the motor by the bridge 11-14 is a square-wave voltage with a frequency equal to the frequency of the supply voltage V1, but phase-shifted with respect to it. The voltage Vm across the motor is the algebraic sum of the two voltages V1 and V2. The phase shift between the voltages V1 and V2 is obtained by operating the controlled switches 11-14 of the full bridge and is controlled in such a way that it always supplies the motor 3 at a design voltage, independently of the voltage of the source 1. In the diagram in Fig. 4, it will be seen that the mains voltage V1 is greater than the motor supply voltage Vm. In practice, it is advantageous to make the control circuit impart a phase to the voltage V2 such that there is always a subtraction from the mains voltage V1, although, as will be clear to a person skilled in the art, the circuit can also operate in the opposite way. This means that the motor is designed for a rated voltage value Vm which is lower than the minimum value which can be supplied by the mains. For example, for a motor suitable for operation in a voltage range of 210-240 V, the design voltage of the motor will be equal to or less than 210 V.

If the mains voltage V1 varies for any reason, the control logic 17 will modify the switching phase of the switches 11, 12, 13 and 14 in such a

way as to phase-shift the square-wave voltage V2 in a different way with respect to the mains voltage V1 to keep the sum Vm of the two voltages equal to the design value of the motor.

The diagram in Fig. 4 shows four time intervals T1, T2, T3 and T4 which correspond to the four states assumed in sequence by the control circuit in Fig. 1, according to the direction of flow of the current supplied by the voltage source 1 and the states of opening and closing of the switches 11, 12, 13, 14 of the full bridge. Figs. 3A-3D show the switching conditions of the switches and the direction of flow of the current in the circuit for each of the four intervals T1-T4.

Fig. 3A shows the power supply circuit of the motor 3 during the interval T1 which starts at the instant (t0) at which the switches 11-14 of the bridge are switched and the voltage V1 is positive. Switches 11, 13 are open (OFF state), while switches 12 and 14 are closed (ON state). In the first part of the period T1, the polarity of the capacitor 19 matches the polarity of the voltage source 1, so that the voltage V2 across the terminals of the capacitor 19 is added to the mains voltage V1. The capacitor 19 discharges, supplying current to the motor 3. This is reflected in a slight decrease of the voltage Vc across the terminals of the capacitor in the interval T1 (see also Fig. 5E). However, the capacitance of the capacitor 19 is such that this voltage variation is minimized.

The current Im in the motor has a sinusoidal variation which is phase-shifted with respect to the variation of the mains voltage V1 and, at the end of the interval T1 (at the instant t1), it passes through the zero value, changing the direction of flow. At the instant t1, the circuit assumes the configuration in Fig. 3B, which is maintained for the time interval T2 (t2-t1): the current Im flows through the capacitor 19 in a direction such that it is charged, as may be seen from the slightly increasing trend of the voltage Vc (see also Fig. 5E) in the interval T2 and energy, in the form of the reactive energy of the motor 3, is stored in the capacitor 19.

At the instant t2, determined by the control logic 17 of the circuit in the way described later on, the switches 11, 12, 13 and 14 of the bridge are switched: switches 11, 13 are closed (ON state) and switches 12, 14 are opened (OFF state), while the current Im in the motor continues to flow in the same direction. The circuit assumes the configuration in Fig. 3C. The voltage applied by the bridge changes sign and becomes negative. The current in the capacitor 19 now flows in such a direction that energy is transferred from the capacitor to the motor, discharging the capacitor (the curve Vc is descending slightly).

At the instant t3, the current Im passes through the zero value and again changes its direction of flow. The circuit assumes the configuration in Fig. 3D: the reactive energy of the motor is transferred to the capacitor 19, which is charged. This state persists up to the next switching of the bridge 11, 12, 13, 14 at the instant t4, at which an operating cycle identical to that described recommences, starting from the instant of switching of the switches 11, 12, 13, 14.

As may be seen in Fig. 4, the instants of switching of the bridge 11, 12, 13, 14, which determine the phase of the square wave V2 with respect to the mains voltage V1, are delayed in such a way that the voltage V2 which is added algebraically to the voltage V1 maintains a voltage across the terminals of the stator winding of the motor 3 which is less than the mains voltage. This is on the assumption that the motor has been designed for a rated voltage lower than the mains voltage, for example on the assumption that the design voltage is 210 V and the mains voltage is 230 V. If the mains voltage V1 undergoes a change, the control logic 17 modifies the phase of the square-wave voltage V2 in such a way that the design voltage of 210 V is still produced across the terminals of the stator winding of the motor. Similar behaviour can take place if the design voltage is greater than the mains voltage, in which case the phase of the square wave V2 will be selected in such a way as to increase the voltage across the terminals of the motor with respect to the mains voltage.

The full bridge 11, 12, 13, 14 is caused to switch by finding the phase of the mains voltage V1 and the value of the voltage across the terminals of the motor 3, and then switching the switches 11, 12, 13, 14 in such a way as to obtain the desired phase for the square wave V2 so that the voltage to the motor remains at the desired value.

The control logic 17 which causes the switching of the bridge 11, 12, 13, 14 may have the configuration shown in Fig. 2. The waveforms of the various signals in the control logic 17 are reproduced in Figs. 6A-6I.

A signal corresponding to the mains voltage V1, whose variation is represented in Fig. 6A, is applied to the input of a zero-crossing detector 21. At the output of the detector 21 there is a periodic signal (see Fig. 6B) in phase with the mains voltage V1, which is sent to the input of a first ramp generator 23. The signal at the output of the detector 21 is also sent to an inverter 25, at whose output is obtained a signal which is inverted with respect to the output signal of the detector 21 (Fig. 6C), and which is sent to the input of a second ramp generator 27. Two identical waveforms, one in phase with the mains voltage V1 and the other phase-shifted by 90°

with respect to it, as shown in Figs. 6D and 6E, are obtained at the outputs of the two ramp generators. The two signals at the outputs of the ramp generators 23, 27 are sent to a first input of two corresponding comparators 29, 31, to whose second input is applied an error voltage (Verr) proportional to the difference between the design voltage of the motor (Vp) and the mains voltage (V1).

A square wave having a rising front coinciding with the point of intersection of each ramp with the error voltage Verr, and having a descending front coinciding with the descending front of each ramp, is obtained at the output of the first comparator 29. The output signal of the comparator 29 is shown in Fig. 6F in solid lines. A signal which is similar, but phase-shifted by 90°, is obtained at the output of the comparator 31 (Fig. 6G; signal shown in solid lines).

When the two output signals of the two comparators 29, 31 are sent to the set and reset inputs of a flip-flop 33, a square-wave signal is obtained at the output of the latter for switching the switches of the full bridge 11, 12, 13, 14, this signal having a duty cycle of 50% and a phase, with respect to the mains voltage V1, which is a function of the value of the error voltage Verr, since the position of the rising front of the two output signals of the comparator 29, 31 depends on this error voltage. The output signal of the flip-flop 33 in the presence of an error voltage Verr is shown in Fig. 6H.

Figs. 6D to 6I also show how the phase of the switching signal generated by the flip-flop 33 varies with a variation of the error voltage. Figs. 6D and 6E show in broken lines a different value of the error voltage V'err, which causes the generation of output signals of the comparators 29, 31 indicated in broken lines in Figs. 6F and 6G. These two signals, applied to the set and reset inputs of the flip-flop 33, generate the switching signal indicated in Fig. 6I. This last signal has the same frequency as the signal in Fig. 6H, but is phase-shifted with respect to it.

Fig. 7 shows the spectrum of the harmonic content of the voltage applied to the motor. As shown in the diagram, the harmonics of the base signal at 50 Hz are negligible, with considerable advantages over the situation which occurs when the voltage is controlled by triac slicers.

It is to be understood that the drawing shows only one practical embodiment of the invention, which may vary in its forms and arrangements without departure from the scope of the concept on which the invention is based. The presence of any reference numbers in the following claims has the purpose of facilitating the reading of the claims in

the light of the preceding description and the attached drawings, and does not limit the scope of protection of the claims.

CLAIMS

1. Circuit for controlling the power supply voltage of an electric motor, including means for measuring a difference between a mains voltage (V1) and a reference voltage (Vp), and means (11-14, 17) for generating an alternating correction voltage (V2) whose frequency is equal to the frequency of the mains voltage (V1) and which is phase-shifted with respect to said mains voltage (V1), characterized in that the phase shift between the mains voltage and the correction voltage is proportional to the difference between the mains voltage and the reference voltage, and said correction voltage (V2) is added to the mains voltage (V1).

2. Circuit according to Claim 1, characterized in that said means for generating said correction voltage comprise a full bridge consisting of four controlled switches (11, 12, 13, 14) whose switching generates the correction voltage (V2), said correction voltage being a square-wave voltage, and a control logic (17) for causing the switching of said controlled switches (11, 12, 13, 14), a virtually continuous voltage source being located in one direct-current branch (18) of said full bridge.

3. Circuit according to Claim 1 or 2, characterized in that it comprises a storage device (19) for storing reactive energy of the motor supplied by said circuit, said storage device (19) supplying energy to the means for generating the correction voltage (V2).

4. Circuit according to Claim 2 and 3, characterized in that said storage device comprises a capacitor located in the direct-current branch (18) of the full bridge.

5. Circuit according to Claim 2 at least, characterized in that said control logic comprises means (21) for generating a signal (B, C) indicating the phase of the mains voltage (V1), means for comparing a signal proportional to the mains voltage (V1) with a reference value (Vp) and for generating an error signal (Verr), comparator means (29, 33) for generating a signal (F, G) which is phase-shifted with respect to said mains voltage (V1) by an amount proportional to said error signal (Verr), and means (33) for obtaining, from said phase-shifted signal, a signal (H; I) for switching the controlled switches.

6. Circuit according to Claim 5, characterized in that said control logic comprises a zero-crossing detector (21) which generates a signal in phase with the mains voltage (V1), a pair of ramp generators (23, 27) to whose inputs is applied the signal generated by the zero-crossing detector (21) and an inverted signal, a pair of comparators (29, 31), to a

first input of which is applied the output signal of the two ramp generators (23, 27) and to a second input of which is applied an error voltage (Verr) proportional to the difference between the mains voltage (V1) and the reference voltage (Vp), and a flip-flop (33) to whose set and reset inputs are applied the output signals of said two comparators (29, 31), the output of said flip-flop being used for switching said controlled switches.

7. Electric motor (3) comprising means of power supply at a controlled voltage (Vm), characterized in that said power supply means include a circuit according to one or more of claims 1 to 6.

8. Electric motor according to claim 7, characterized in that it is a single-phase asynchronous motor.

9. Method for supplying an electric motor (3) with a controlled voltage (Vm), including the step of generating a low alternating correction voltage (V2), whose frequency is equal to a supply voltage (V1) and which is phase-shifted with respect to said supply voltage, characterized in that said correction voltage is phase-shifted with respect to said supply voltage by a value proportional to the difference between the supply voltage (V1) and a reference voltage (Vp).

10. Method according to claim 9, characterized by adding said correction voltage (V2) to said supply voltage (V1).

11. Method according to Claim 9 or 10, characterized in that said correction voltage (V2) is generated by means of the inductive energy of the motor (3).

12. Method according to Claim 9 or 10 or 11, characterized in that said correction voltage (V2) is a square-wave voltage.

13. Method according to one or more of Claims 9 to 12, characterized by supplying said motor by means of a full bridge of controlled switches (11, 12, 13, 14), by arranging a substantially continuous voltage supply (19) in one direct-current branch (18) of said full bridge, and by modifying the phase of the switching of said switches as a function of said difference between the supply voltage (V1) and the reference voltage (Vp).

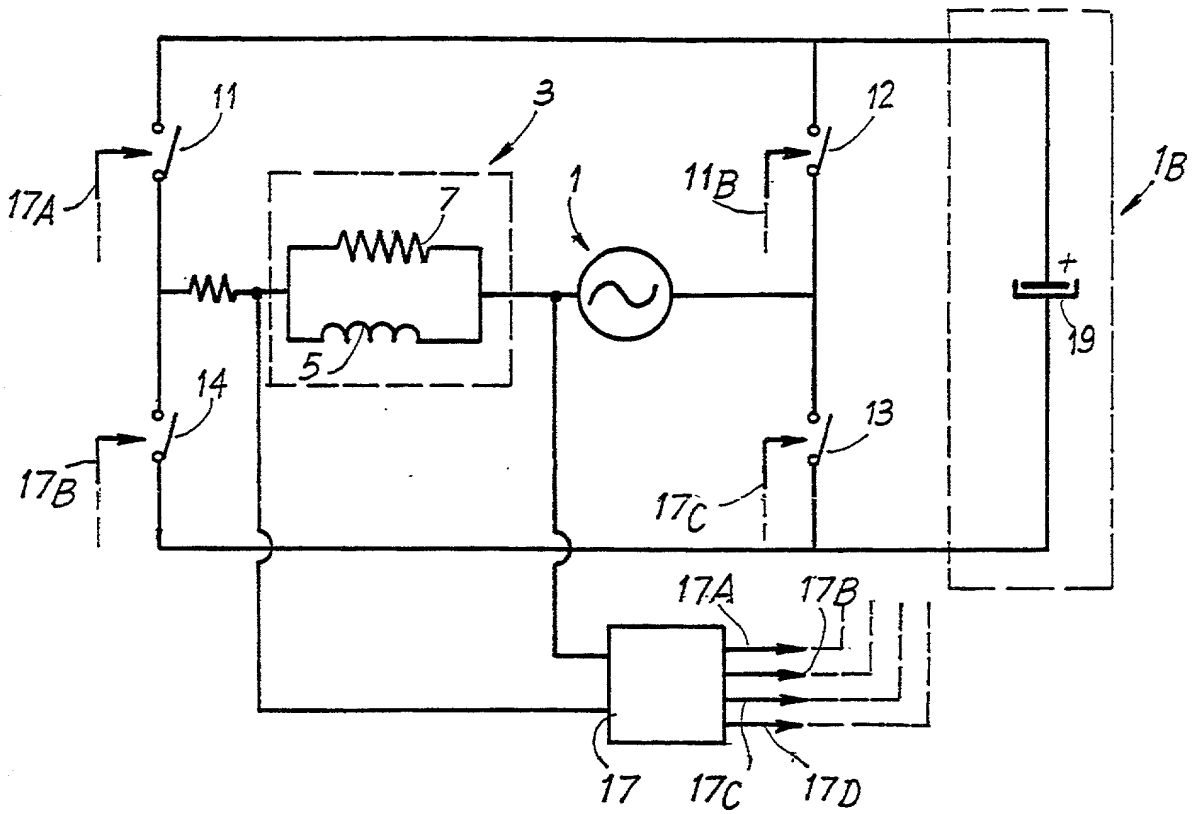
14. Method according to Claims 11 and 13, characterized in that said substantially continuous voltage source (19) consists of a capacitor (19) which is charged by means of the inductive energy of said motor.

15. Method according to Claim 13 at least, characterized by: generating a signal (B, C) indicating the phase of the mains voltage (V1); comparing a signal proportional to the mains voltage (V1) with a

reference value (Vp) and generating an error signal (Verr) proportional to the difference between the mains voltage and the reference value; generating a signal (F, G) which is phase-shifted with respect to the mains voltage (V1) by an amount proportional to the error signal (Verr); obtaining a signal (H; I) for switching the controlled switches (11, 12, 13, 14) from said phase-shifted signal.

16. Method according to Claim 15, characterized by: generating a signal (B) detecting the zero-crossing of the mains voltage (V1) and a corresponding inverted signal (C); generating two corresponding ramp signals (D, E); comparing said ramp signals with said error signal (Verr) and generating two comparison signals (F, G); and generating the signal (H; I) for switching the controlled switches (11, 12, 13, 14) from the comparison signals (F, G).

Fig.1


11
3
12
1B
17A
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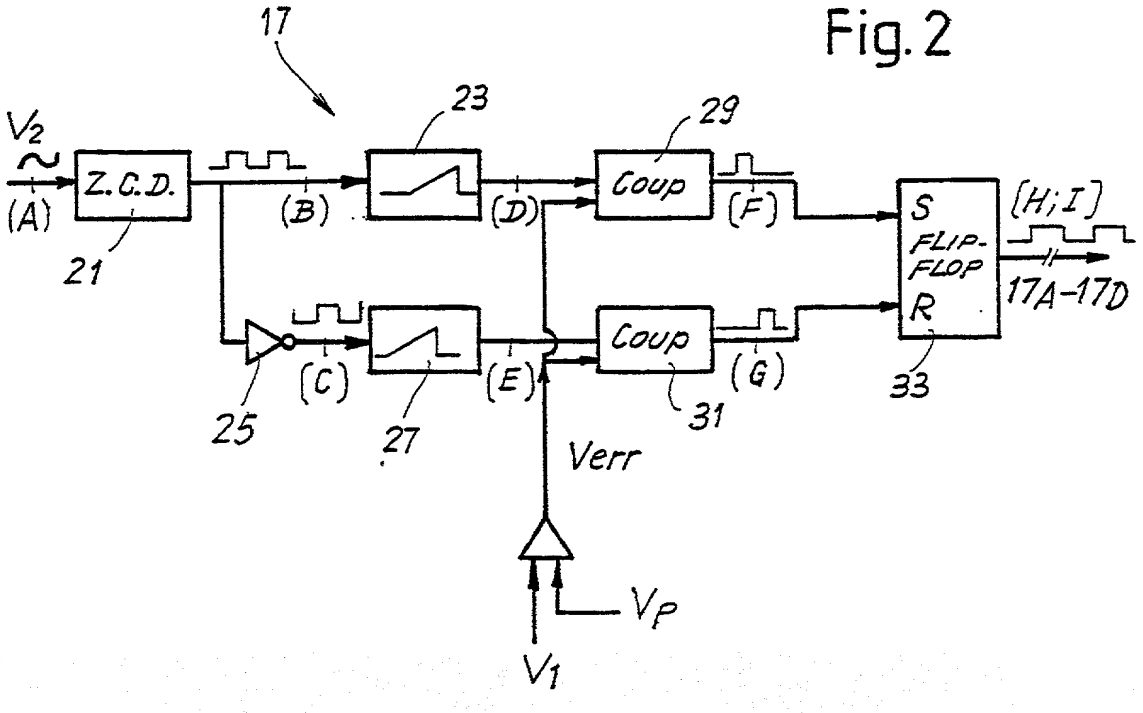
17C
17D

Fig. 2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23
29
V2
Z.C.D.
Coup
S
FLIP-
FLOP
R
(H;I)
17A-17D
(A)
(B)
(D)
(F)
21
(C)
(E)
(G)
25
27
31
33
Verr
VP
V1

Fig.3A

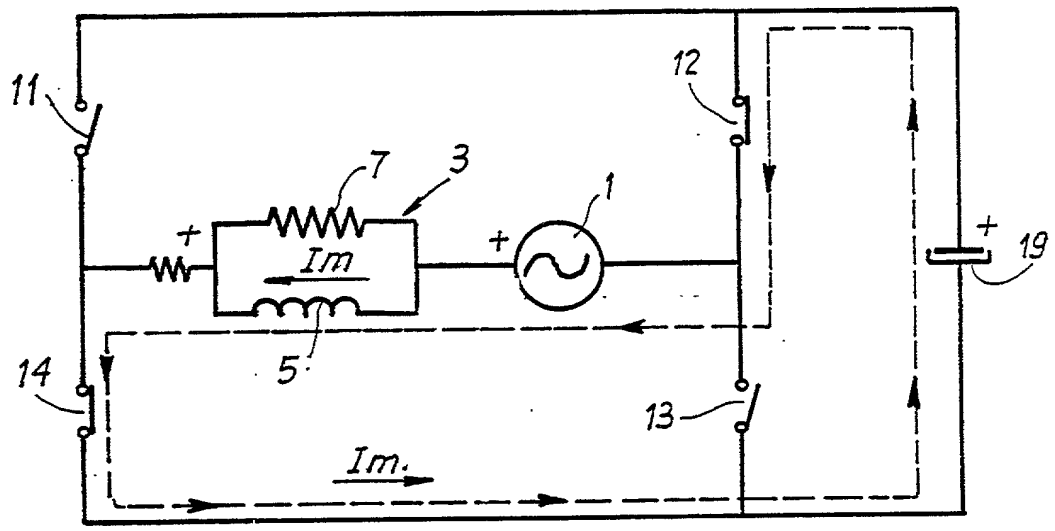


Fig.3B

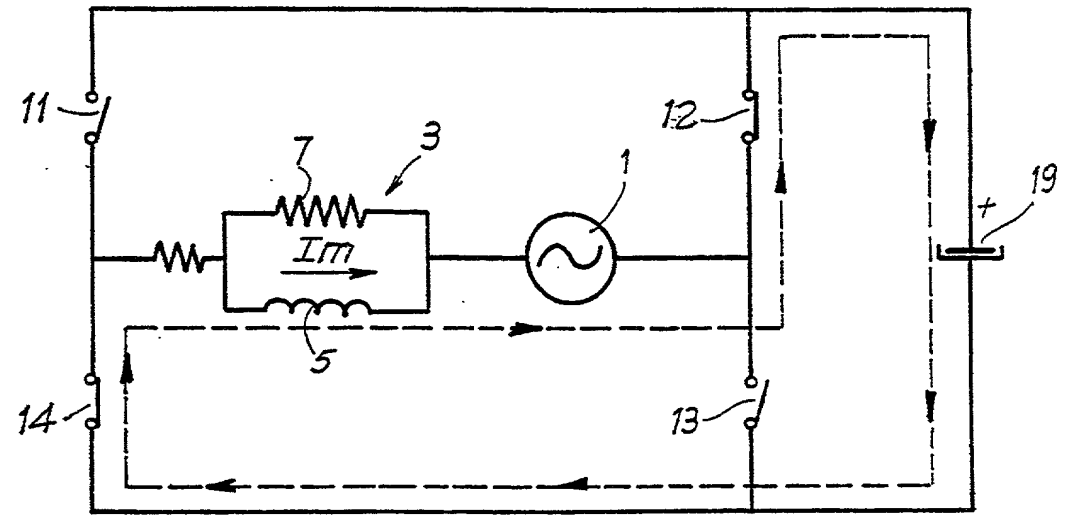


Fig.3C

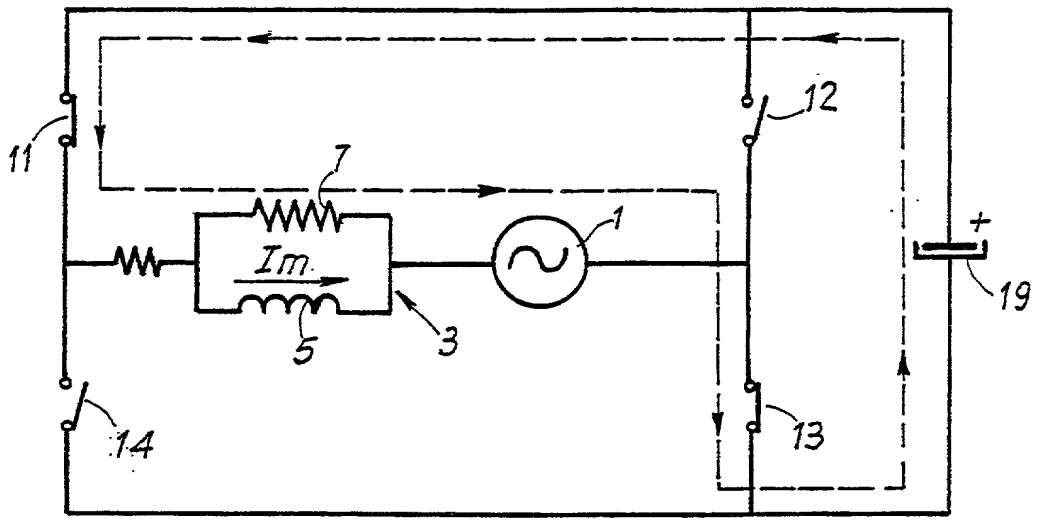


Fig.3D

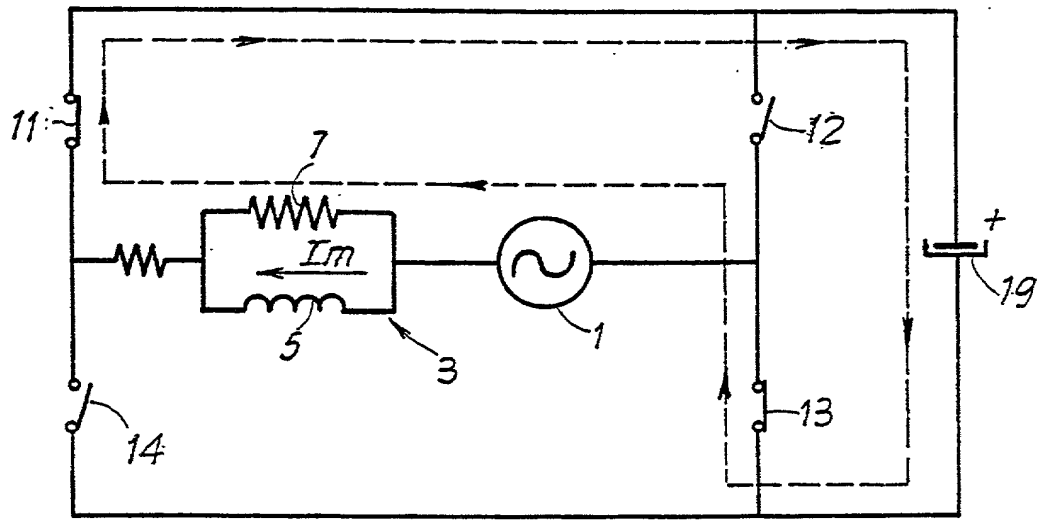
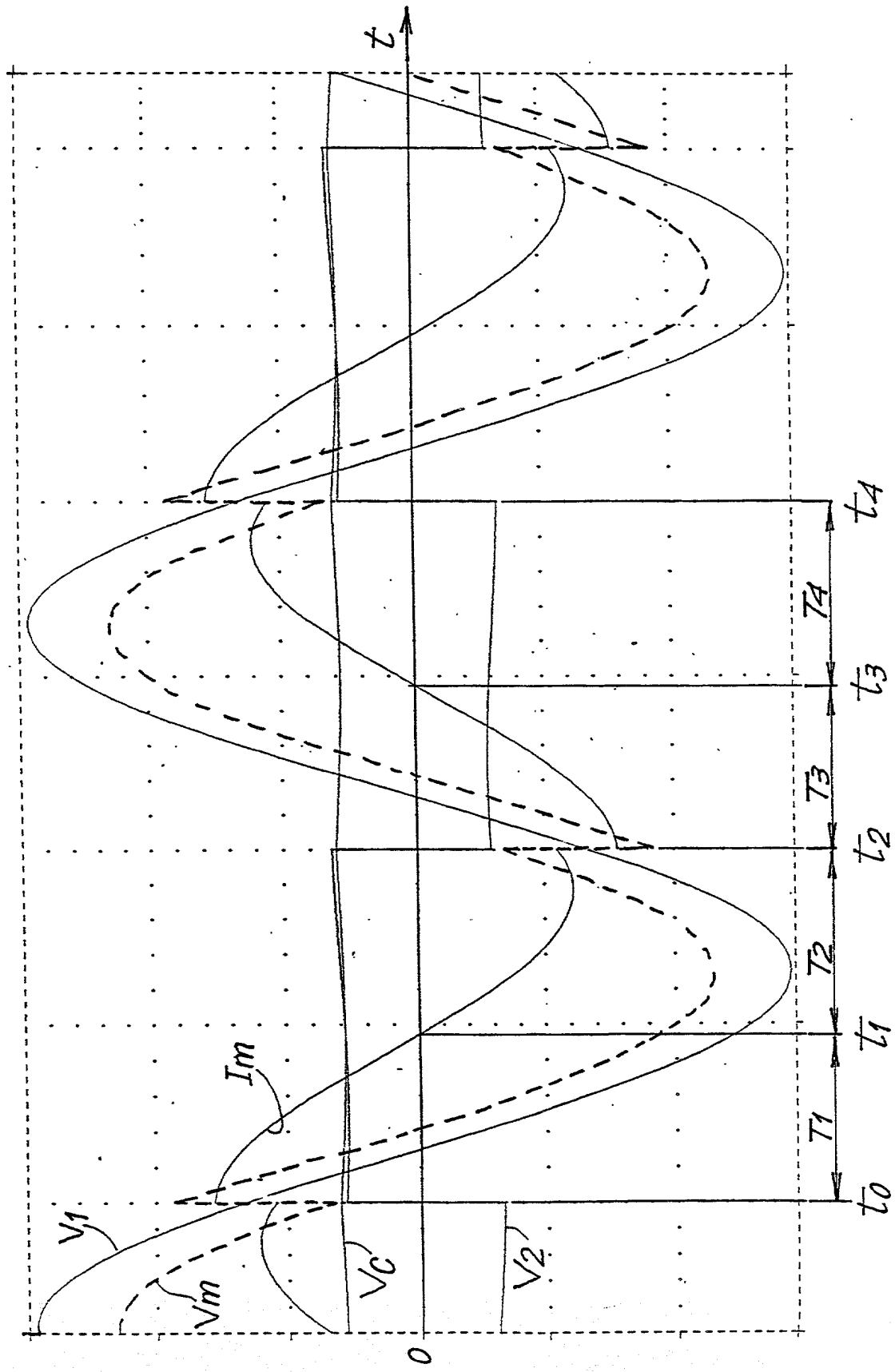


Fig. 4



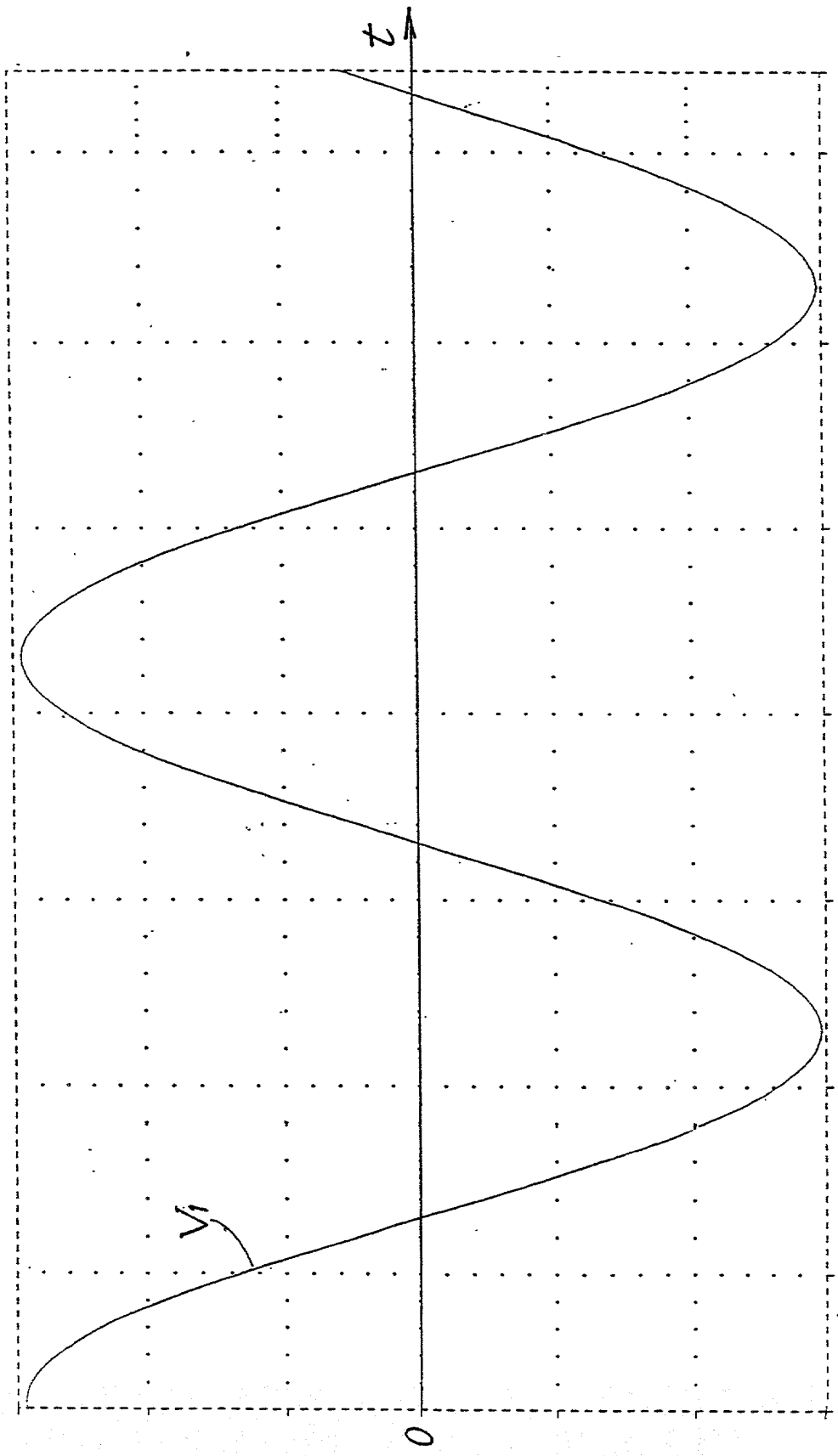


Fig. 5A

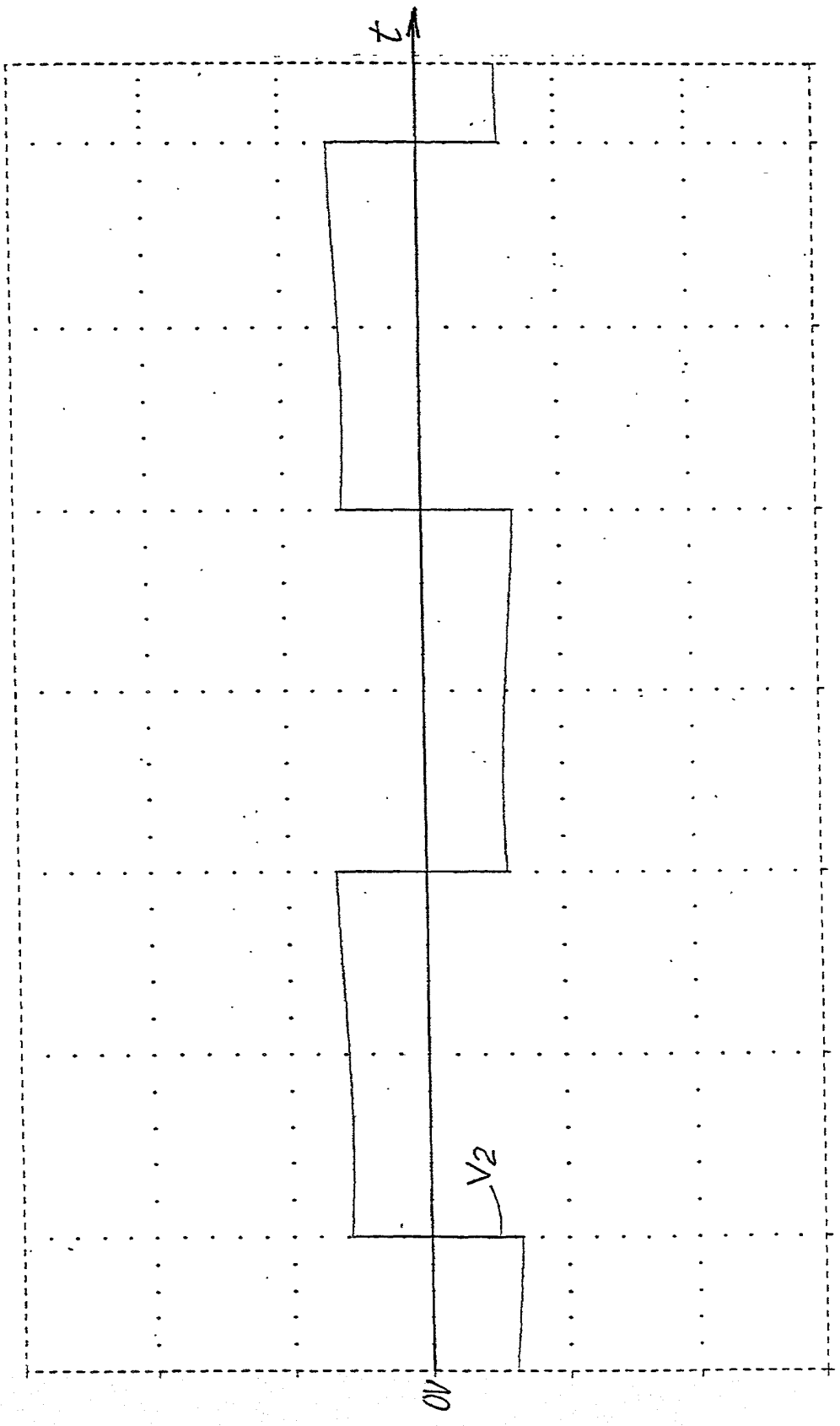


Fig. 5B

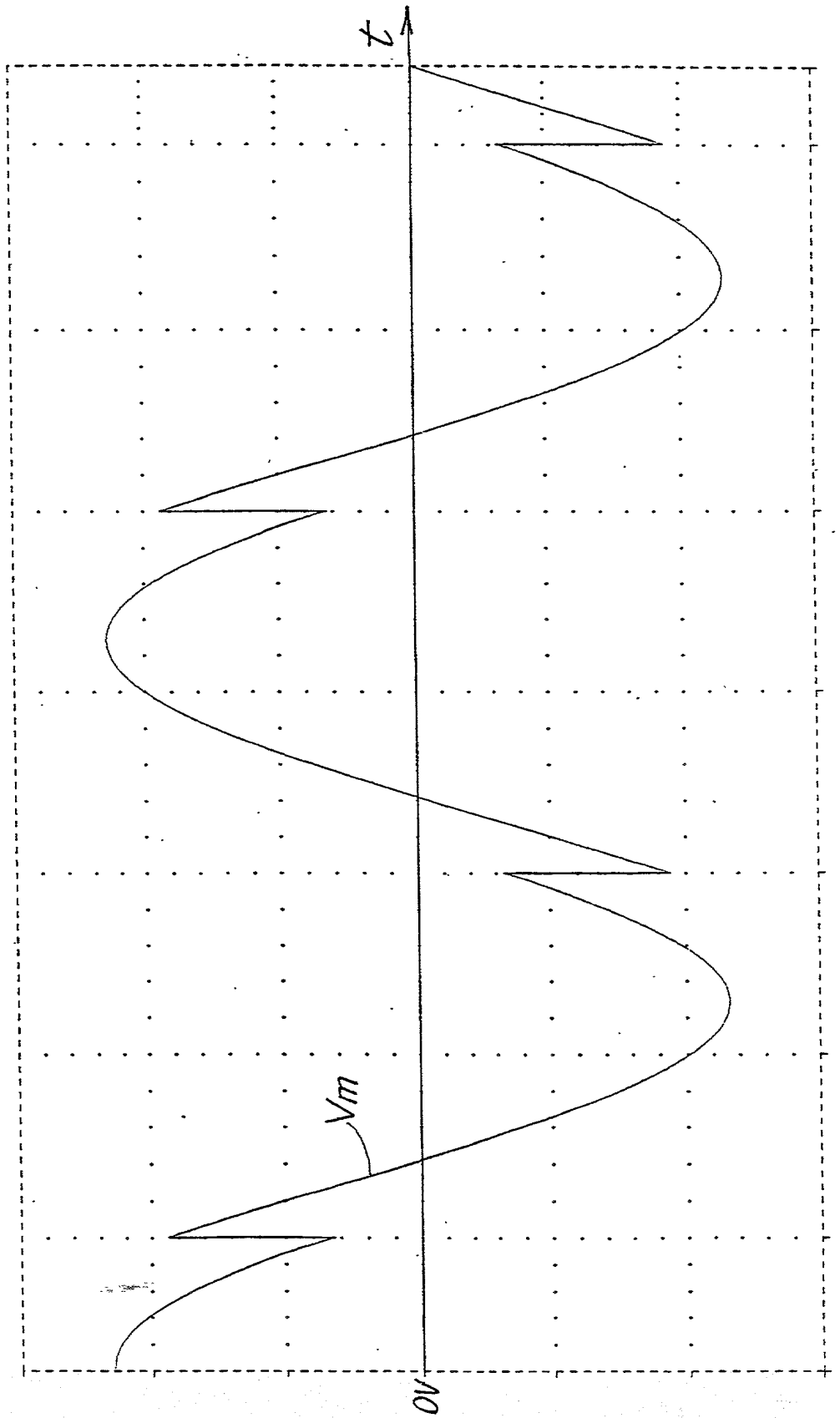


Fig.5C

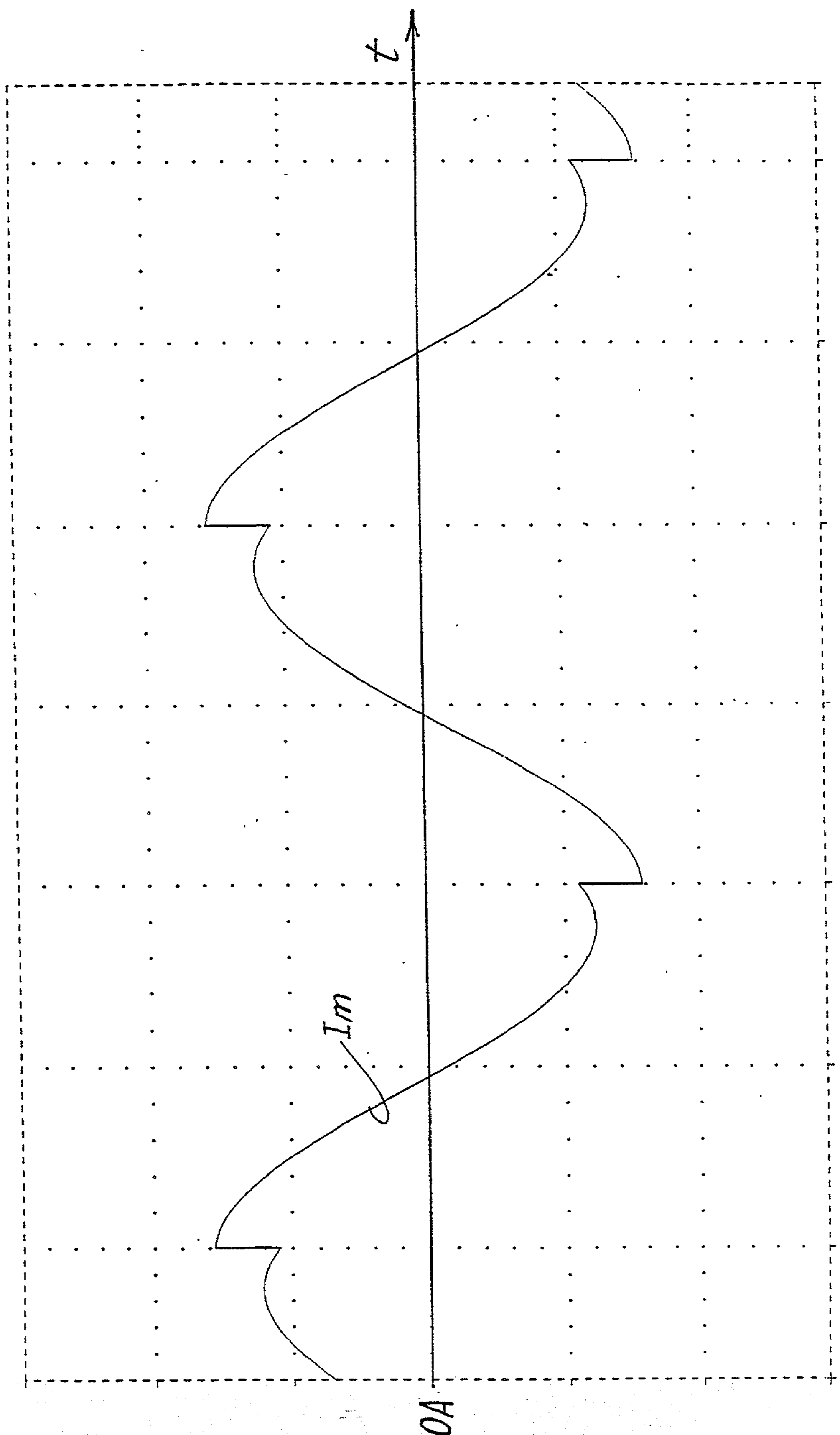


Fig.5D

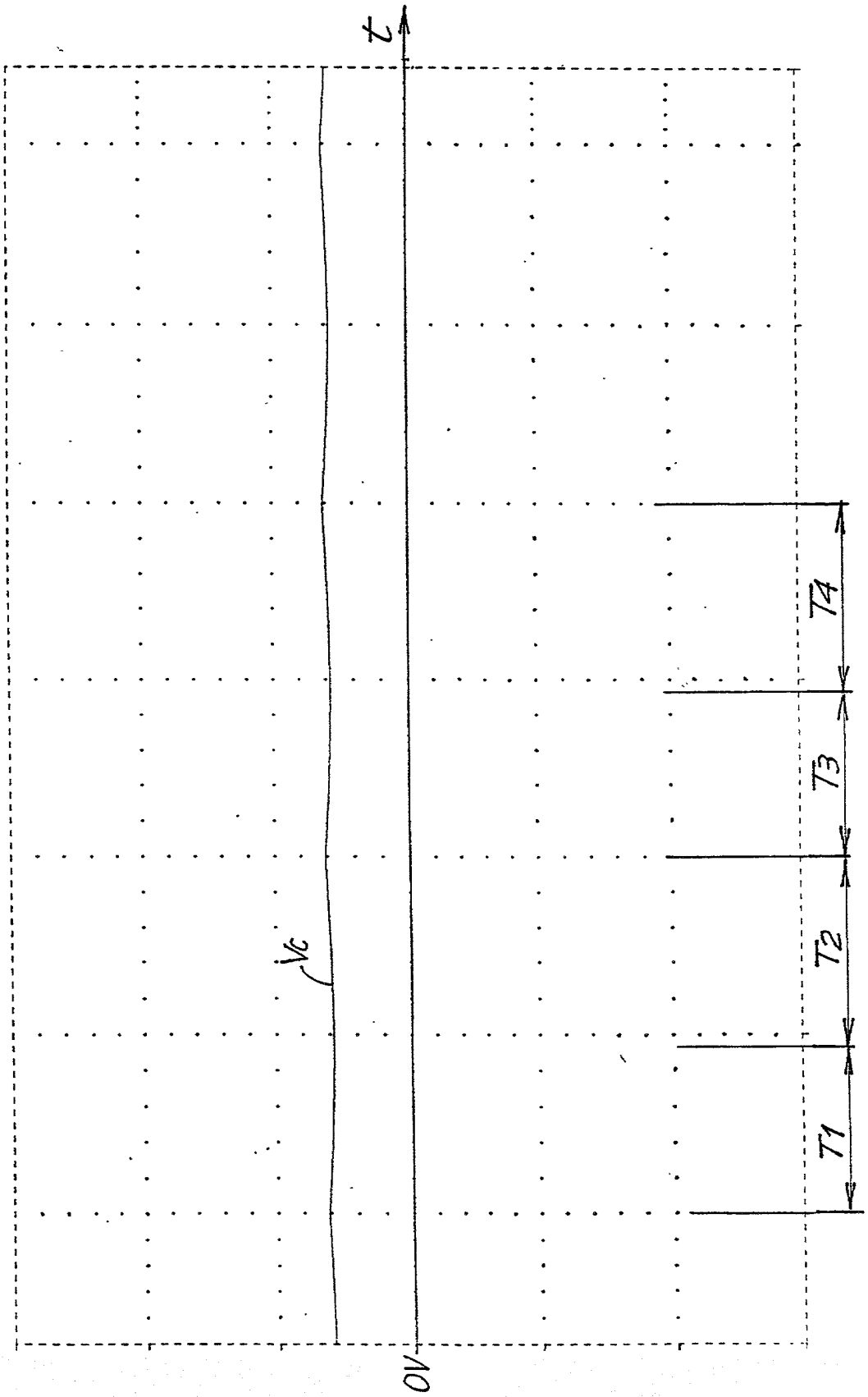


Fig. 5E

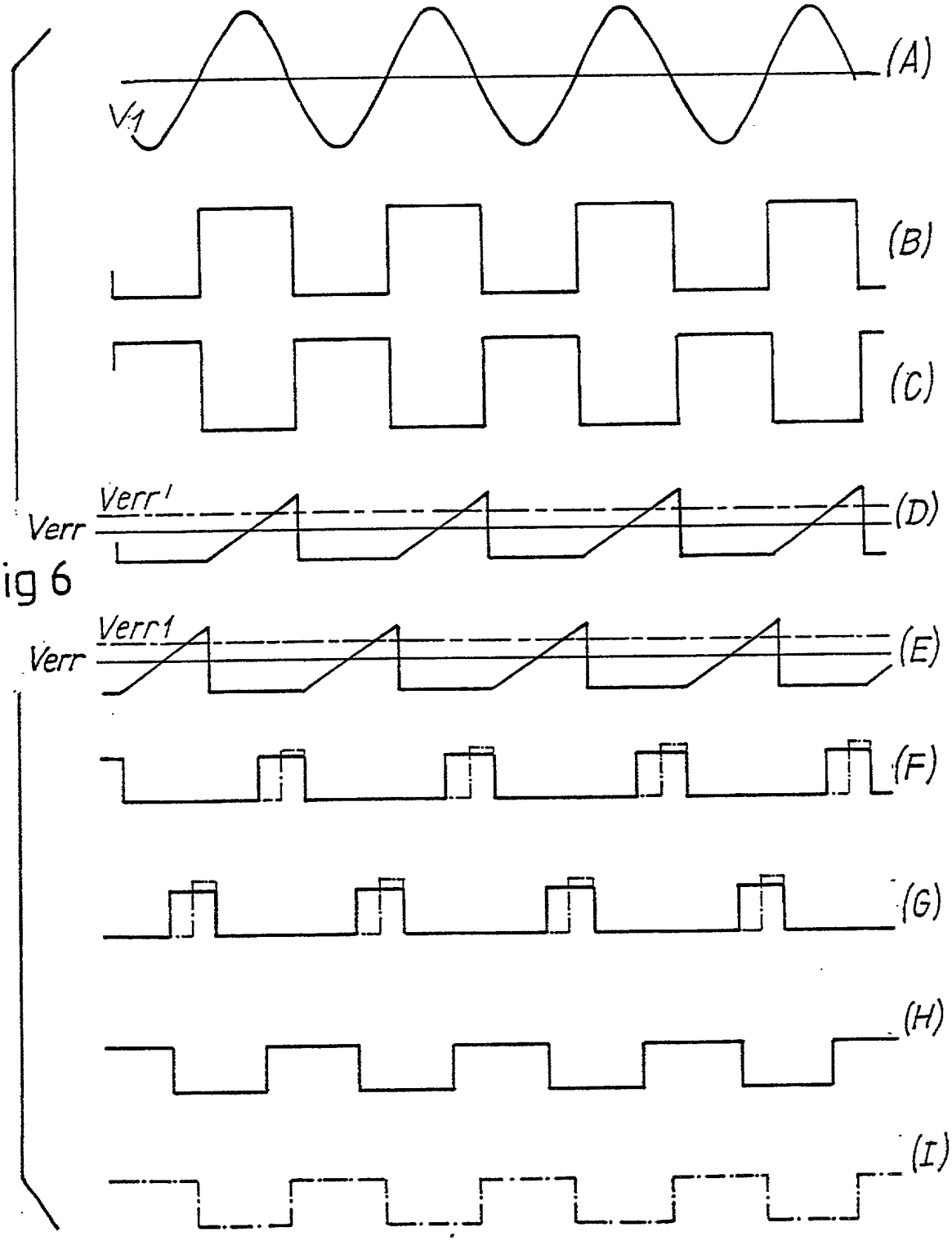


Fig 6

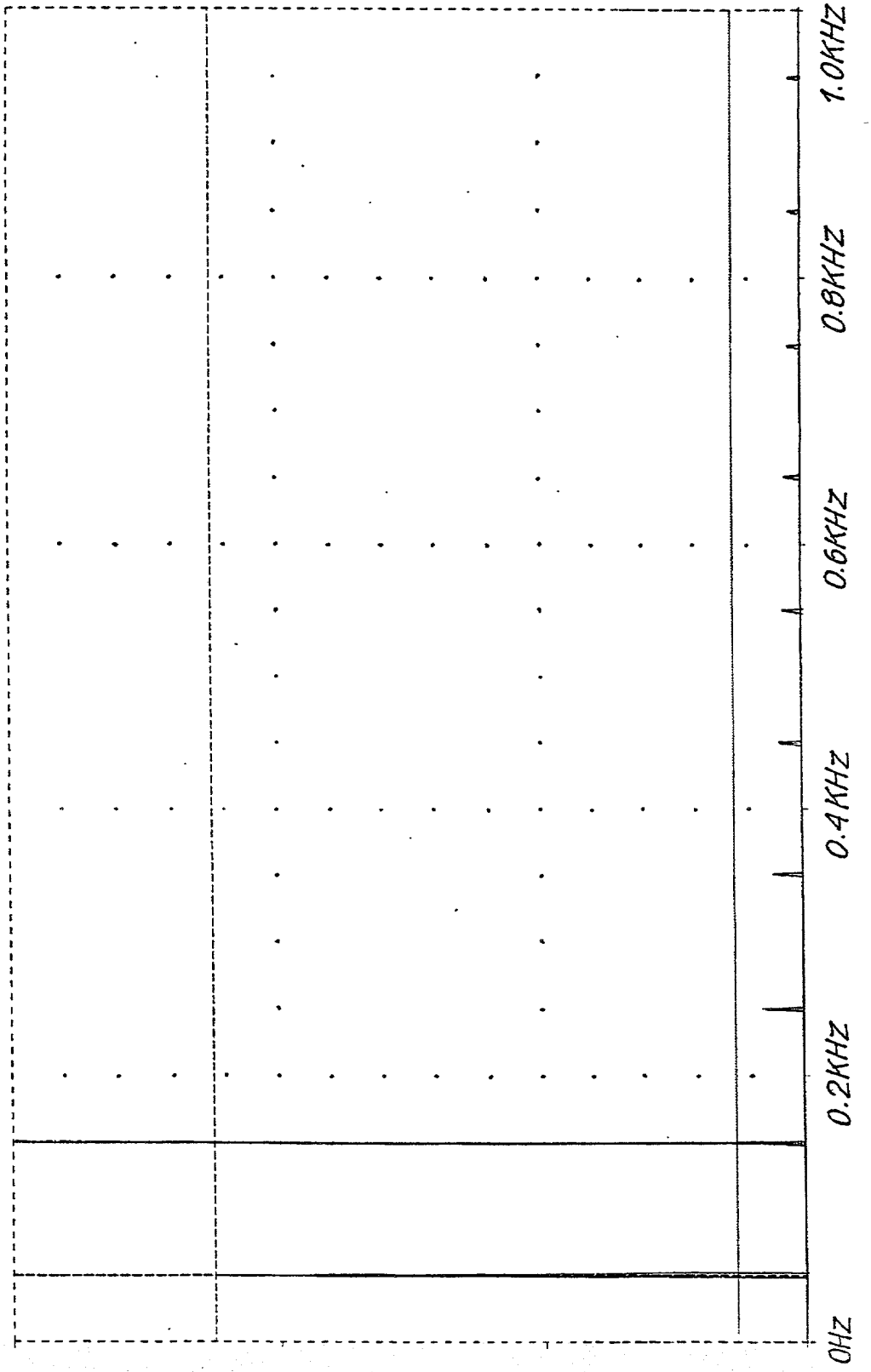


Fig.7

PTO/SB/104 (8-96)
Approved for use through 9/30/98. OMB 0651-0032
Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

Declaration and Power of Attorney for Patent Application

Dichiarazione e procura ai fini della domanda di brevetto

Italian Language Declaration

Il sottoscritto inventore dichiara che:

La propria residenza, recapito postale e cittadinanza corrispondono a quanto indicato in calce, sotto la propria firma.

Ritiene di essere il primo ed unico inventore originale (se viene elencato in calce un solo nominativo) o il coinventore primo ed originale (se è elencato più di un nominativo) del oggetto rivendicato e per il quale il sottoscritto presenta domanda di brevetto. La invenzione in questione è chiamata

_____

_____

e la sua descrizione è allegata alla presente Dichiarazione a meno che non sia spuntata la seguente casella:

☐ Il _____
è stata depositata una domanda di brevetto statunitense numero o una domanda di brevetto internazionale PCT numero
_____ che è stata modificata il
_____ (se applicabile).

Il sottoscritto dichiara in oltre di aver letto e compreso il contenuto della descrizione identificata in precedenza, rivendicazioni comprese, come modificati dall'eventuale modifica summenzionata.

Il sottoscritto riconosce l'obbligo di rivelare informazioni essenziali ai fini della determinazione della brevettabilità ai sensi del Titolo 37, Codice dei Regolamenti Federali, § 1.56.

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled

POWER SUPPLY CIRCUIT OF AN ELECTRIC MOTOR AND CORRESPONDING CONTROL METHOD

the specification of which is attached hereto unless the following box is checked:

☒ was filed on 26.06.2000
as United States Application Number or PCT International Application Number
PCT/~~IT00/00261~~ and was amended on
_____ (if applicable).

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, § 1.56.

Italian Language Declaration

Il sottoscritto rivendica con la presente la priorità prevista dal Titolo 35, Codice degli Stati Uniti, § 119(e)-(d) o § 365(b) in relazione a qualsiasi domanda o domande estere di brevetto o certificato di inventore, o dal Titolo 35, § 365(a) degli stessi Codice in relazione a qualsiasi domanda internazionale PCT nella quale è designato almeno un paese diverso dagli Stati Uniti, i suddetti domande e certifcati essendo elencati sotto, e, spuntando les seguenti caselle, ha anche identificato sotto qualsiasi domanda estera di brevetto o certificato di inventore, o domanda internazionale PCT, la cui data di deposito preceda quella della domanda per la quale è rivendicata la priorità.

I hereby claim foreign priority under Title 35, United States Code, § 119(a)-(d) or § 365(b) of any foreign application(s) for patent or inventor's certificate, or § 365(a) of any PCT International application which designated at least one country other than the United States, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate or PCT International application having a filing date before that of the application on which priority is claimed.

Prior Foreign Aplication(s)
Domande Estere Anteriori

Priority Not Claimed
Diritto di priorità non rivendicato

(Number) (Numero)	(Country) (Nazione)	(Day/Month/Year Filed) (Giorno/Mese/Anno di deposito)	
99830423.2	EUROPEAN PATENT	02.07.1999	☐
			☐

Il sottoscritto rivendica con la presente i benefici previsti dal Titolo 35, Codici degli Stati Uniti, § 119(e), in relazione a qualsiasi domanda o domande provvisorie degli Stati Uniti elencate sotto.

I hereby claim the benefit under Title 35, United States Code, § 119(e) of any United States provisional application(s) listed below.

(Application No.) (N° della domanda)	(Filing Date) (Data di deposito)

Il sottoscritto rivendica con la presente i benefici previsti dal Titolo 35, Codice degli Stati Uniti, § 120, in relazione a qualsiasi domanda o domande statunitensi, o dal Titolo 35, § 365(c) degli stessi Codice in relazione a qualsiasi domanda internazionale PCT nella quale sono designati gli Stati Uniti, i suddette domande essendo elencate sotto e, nella misura in cui l'oggetto di ciascuna rivendicazione di questa domanda non sia stato esposto nella domanda statunitense o internazionale PCT anteriore nel modo previsto dal primo paragrafo del Titolo 35, Codice degli Stati Uniti, § 112, riconosce l'obbligo di rivelare informazioni essenziali ai fini della determinazione della brevettabilità ai sensi del Titolo 37, Codici dei Regolamenti Federali, § 1.56, le quali diventino disponibili durante il periodo compreso tra la data di deposito della domanda anteriore e la data di deposito nazionale o internazionale PCT della presente domanda.

I hereby claim the benefit under Title 35, United States Code, § 120 of any United States application(s), or § 365(c) of any PCT International application designating the United States, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of Title 35, United States Code, § 112, I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, § 1.56 which became available between the filing date of the prior application and the national or PCT International filing date of this application.

(Application No.) (N° della domanda)	(Filing Date) (Data di deposito)	(Status) (patented, pending, abandoned) (Stato) (concessione di brevetto, in corso di esame, abbandono)

Con la presente, il sottoscritto dichiara veritiere tutte le affermazioni contenute in questa domanda in relazione alle proprie conoscenze e di ritenere vere tutte le affermazioni o informazioni presentate. Dichiara inoltre che tali asserzioni sono state espresse nella piena consapevolezza che le dichiarazioni intenzionalmente false sono punibili con una multa, l'incarcerazione o entrambe, ai sensi della Sezione 1001 del Titolo 18 del Codice degli Stati Uniti e che tali dichiarazioni intenzionalmente false possono mettere a repentaglio la validità della domanda o di qualsiasi brevetto rilasciato in merito.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Italian Language Declaration

PROCURA: Il sottoscritto inventore nomina con la presente il seguente avvocato o avvocati e/o agente o agenti al fine di istruire questa pratica e di condurre tutte le operazione ad essa pertinenti presso l'Ufficio dei Brevetti e Marchi di Fabbrica: *(Elencare il nome ed il numero di matricola).*

POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith: *(list name and registration number).*

See Attachment A

Inviare le corrispondenza a:

Send Correspondence to:

Mark J. Patterson, (615) 242-2400

Telefonare a: *(nome e numero telefonico)*

Direct Telephone Calls to: *(name and telephone number)*

414 Union Street, Suite 2020, NationsBank Plaza

Nashville, Tennessee 37219

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Firma dell'inventore Data X	Inventor's signature Date 13.12.2001
Residenza	Residence Via Po 79/4, 52025 MONTEVARCHI AREZZO Italy
Cittadinanza	Citizenship ITALY ITX
Recapito postale	Post Office Address Via Po 79/4 52025 MONTEVARCHI, AREZZO Italy
Nome e cognome dell'eventuale secondo coinventore 2-00	Full name of second joint inventor, if any MARTINI David
Firma del secondo coinventore Data X	Second Inventor's signature Date 13.12.2001
Residenza	Residence Via Garibaldi 21 - 52028 S. GIOVANNI VALDARNO, AREZZO Italy
Cittadinanza	Citizenship Italy ITX
Recapito postale	Post Office Address Via Garibaldi 21, 52028 S.GIOVANNI VALDARNO, AREZZO ITALY

(Fornire le stesse informazioni e le firme del terzo e degli ulteriori coinventori.)

(Supply similar information and signature for third and subsequent joint inventors.)

ATTACHMENT A

(5)

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